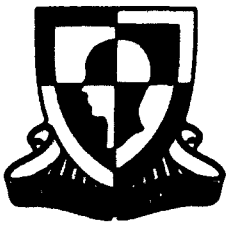

U.S. Army Research Institute
for the Behavioral and Social Sciences

Research Report 1654

Trial Application of the Embedded Training Guide to an Armored System: Lessons Learned

Bob G. Witmer
U.S. Army Research Institute

November 1993

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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In June 1991, the U.S. Army Research Institute for the Behavioral and Social Sciences published "A Guide for Early Embedded Training Decisions." That document, for the first time, provided the Army with specific procedures for determining what training to embed in weapons systems and what to train by other means. This report describes a trial application of the embedded training (ET) guide for a proposed armored weapons system. It describes the procedures used to apply the ET guide and the lessons learned from that application. Included are procedures for compiling and clustering tasks and source documentation for the enbedded training analysis, and suggestions for improving use of the decision flowcharts in performing the analysis. Application of the ET guide to the future armored system demonstrates that the guide can be used to make objective recommendations for using ET for a complex weapons system. Six problems were encountered in using the ET guide, but all were easily corrected with minor alterations to a few of the decision flowcharts and help screens.

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Trial Application of the Embedded Training Guide to an Armored System: Lessons Learned

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Human Performance Effectiveness and Simulation

FOREWORD

In June 1991, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) published "A Guide for Early Embedded Training Decisions." That document, for the first time, provided the Army with specific procedures for determining what training to embed in weapons systems and what to train by other means. The document has been enthusiastically accepted by the Army user community. It has been revised and automated by Simulation, Training, and Instrumentation Command (STRICOM) to facilitate its use.

This report describes a trial application of the embedded training (ET) guide for a proposed armored system. It describes, in detail, the procedures used to apply the ET guide to a developing weapons system and the lessons learned as a result of that application. Included are procedures for identifying and clustering tasks, compiling the supporting documentation, and improving the efficiency of using the decision flowcharts. The guide also includes important lessons for prospective users and offers specific recommendations for the use of embedded training in the Block III tank.

The work described is part of the research task entitled Technology Development for Simulated Training Environments, which is being conducted for STRICOM by the ARI STRICOM, Orlando Field Unit, under a Memorandum of Understanding between STRICOM (formerly PM TRADE) and ARI dated 14 July 1986. A draft version of this report has been presented to STRICOM, and lessons learned are being incorporated into the automated version of the ET guide.

EDGAR M. JOHNSON
Director

TRIAL APPLICATION OF THE EMBEDDED TRAINING GUIDE TO AN ARMORED SYSTEM: LESSONS LEARNED

EXECUTIVE SUMMARY

Requirement:

This research was conducted to test empirically the procedures for making early embedded training decisions in a realistic setting using only resource documents available early in the weapons system acquisition process. This empirical test of the ET guide should result in refinement and, where desirable, elaboration of the decision-making procedures described in the ET guide.

Procedure:

Using a general task listing proposed for the Armored Systems Modernization (ASM) Block III tank, tasks were organized under broad functional categories using the Blueprint of the Battlefield. The tasks in each category were divided into subgroups and task clusters on the basis of commonalities. An analysis of the types of information required for each block of each phase of the ET decision process was performed and the information was compiled using available source documents (e.g., Systems Training Plan). Assumptions were made where available information was insufficient to support the ET decision process. For Phase I, the tasks were divided into institutional and unit training tasks for making ET decisions. For Phases II and III, each task cluster (usually consisting of two or three tasks) was analyzed separately using the decision flowcharts in the ET guide. The charts were annotated during the analysis to record intermediate outcomes and final recommendations.

Findings:

Application of the ET guide to the ASM Block III tank demonstrates that the guide can be used to make objective recommendations about the use of embedded training for a major weapons system program early in the program. Only six problem areas were encountered in using the ET guide, and those were easily addressed by making minor modifications to the flowcharts or text. The most difficult part of the process was bringing all the necessary information together to conduct the embedded training analysis.

Utilization of Findings:

The lessons learned in using the ET guide in this practical application should help in subsequent applications of the ET guide and provide additional guidance to those responsible for making embedded training decisions.

TRIAL APPLICATION OF THE EMBEDDED TRAINING GUIDE TO AN ARMORED SYSTEM: LESSONS LEARNED

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TRIAL APPLICATION OF THE EMBEDDED TRAINING GUIDE TO AN ARMORED SYSTEM: LESSONS LEARNED

Section 1. Introduction

Embedded Training (ET) is training that is provided by capabilities designed to be built into or added onto the weapons system itself. Army policy requires training developers to consider ET first among training options. However, effective implementation of this policy has been hampered by the lack of specific procedures for determining what training should be embedded and what should be provided by other means. Witmer and Knerr (1991) developed a set of guidelines, in the form of detailed decision flowcharts, to assist training developers and engineers in making those early decisions about what training to embed. The flowcharts require the training analyst to consider a number of factors in making decisions about the use of embedded training. Among these factors are policy; system availability for training; the technical feasibility of ET implementation; the effects of ET on system reliability, availability, and maintainability; the impact of ET on system manpower and personnel requirements; the need for training-specific interface hardware; safety; and cost-effectiveness. These factors are incorporated in three sets of flowcharts designed to be used in different stages of the acquisition process.

The guide is designed to assist in determining, early in the acquisition process, what training should be embedded in the prime system, and what should be provided by other means. It treats these decisions as a phased process that is linked to information availability. Tentative decisions must be made initially and then revised as more information becomes available. The guide defines four decision phases. The decision phases are defined by types of information that are available for making training decisions that systematically change during the prime system materiel acquisition cycle.

Phase I and Phase II activities are typically conducted in close succession during the Concept Exploration and Definition Phase (between Milestone 0 and Milestone 1) for the prime system. Phase I requires information on training policies and goals, Manpower, Personnel and Training (MPT) considerations, and projections regarding the extent that ET may interfere with prime system operational capabilities. Phase II requires information about the training environment and results from an early comparability analysis, if available.

Phase III may be conducted as early as Milestone 1, but before Milestone 2, i.e., during the Demonstration and Validation Phase of the prime system acquisition. Phase III requires information from prime system operational requirement documents, the results of a Hardware vs Manpower (HARDMAN) comparability analysis, detailed information about the predecessor system, a description of the prime system concept as produced by the concept formulation process, and information about the soldiers and training resources in the units who are expected to receive the prime system.

Phase IV is also conducted during the Demonstration and Validation phase of the prime system acquisition and requires data and information from simulations, mock-ups, test beds and tests and evaluations. Phase IV could not be addressed in this effort because the development of the weapon system was not far enough along to provide information from simulations, test beds, etc.

The ET Guide is divided into seven sections. An Introduction briefly discusses the problem involved in making embedded training decisions early in the acquisition process and discusses how the guide approaches this problem. A second section describes the characteristics that are needed for successful embedded training, explains the various types of ET, lists the advantages and disadvantages of ET and discusses the principles and assumptions upon which the guide is based. The third section tells who should use the guide and describes how it should be used. The timing of each phase and the necessary information for completing each phase are discussed. Definitions of terms and symbols are also included in this section. The decision flowcharts and help sections for each phase are included in the next three sections. (The flowcharts for phases III and IV are identical). The final section is a simulation based training alternative cost summary. This section includes a cost worksheet for estimating costs of the various training alternatives, including ET.

The worth of ET for a particular application should be determined on the basis of its cost and training effectiveness relative to alternative means of providing the training. The ET guide provides specific procedures for determining the viability of ET relative to other training alternatives.

While the ET Guide has undergone a rigorous review process, it had not been used to make the embedded training decisions for an Army weapons system. The purpose of this report is to describe the application of the procedures in the ET Guide to make embedded training decisions for the Armored Systems Modernization (ASM) Program Block III Tank. While work on the Block III tank has been deferred indefinitely, there is still much that can be learned from applying the Guide to this complex weapons system. Lessons learned from this application may be instructive to those responsible for determining embedded training requirements for other ASM vehicles or, for that matter, for any major weapons system. Even more important from the perspective of the usefulness of the guide, it permits the full exercise of the procedures for making embedded training decisions in a realistic context, thereby highlighting the strengths and weaknesses of the ET Guide.

The Block III Tank, as envisioned by Army planners, would be a sophisticated, highly mobile, full tracked armor fighting vehicle incorporating state-of-the-art advances in armor protection, fire control, power pack and suspension system components. It would consist of a hull and turret with automatic loader and be operated

by a three man crew. In addition to the main gun, it would include an area suppression weapon and a universal weapon platform capable of accepting weapons of the period. The fire controls would be a full resolution, digital system capable of controlling the entire armament and target acquisition system. An advanced target acquisition system with automatic target recognition and prioritization would be included. Command and control would be enhanced by a Vetronics Control and Operating System (VCOS) which would support position navigation, embedded training and communication with the Battlefield Management System. Survivability would be improved through the use of more rugged armor, ammunition and fuel compartmentalization and an improved fire extinguishing system. The vehicle design would also incorporate NBC protection and detectors and a Vehicle Integrated Defense System (VIDS), including state-of-the- art countermeasures and sensors.

The purpose of this report is to describe the application of the ET Guide to the ASM Block III Tank and to record lessons learned concerning the ET Guide and how it may best be used to make ET decisions. Section 1 provides an overview of the ET Guide, a brief description of the Block III Tank and of the contents of this report. Section 2 of the report describes the methods used in applying the ET Guide to the Block III Tank. Procedures for compiling and clustering tasks for the analyses, procedures for compiling the supporting documentation, as well as procedures for using the decision flowcharts are included. Section 3 identifies problems in applying the ET Guide and proposes solutions to these problems. Sections 4 through 6 of the report list, the assumptions and factual documentation required to support each analysis phase and discusses specific recommendations regarding the use of embedded training in the Block III Tank. The unavailability of specific data needed to perform the analysis in some cases forced us to make assumptions about the Block III Tank. For example, none of the supporting documentation clearly indicated that adequate range facilities would be available for training with the Block III tank. Therefore, we assumed that to the extent that range facilities support current tank training, they should also support Block III Tank training. This assumption and others were reasoned estimates based on the best available information. Section 7 briefly describes the conclusions derived from the trial application of the ET Guide. Section 8 is a list of references used in performing the analyses.

Section 2. Analysis Procedures

Rationale for Conducting the Analysis

The analysis of the Block III tank was performed by the author using source documents and other information acquired through participation in the Armored Systems Modernization (ASM) program. The analysis was conducted as an additional test of the logic incorporated in the decision flowcharts and as a reality check on availability of the necessary information for conducting the analysis. Expected benefits of applying the ET Guide to the Block III Tank include, in addition to specific results for the Block III, application guidance for first-time users in subsequent applications of the guide. While this analysis was conducted by a single analyst to expedite testing the logic of the decision flowcharts contained in the ET Guide, future analyses of real world systems should be accomplished using several subject matter experts to include combat developers, training developers and materiel developers.

Compiling and Clustering Tasks

A first step in using the ET Guide is to identify those tasks and functions for which the training media decisions must be made. A Draft Block III task list (U.S. Army Armor School (USAARMS), August 1991a) organized by crew position (i.e., Tank Commander, Gunner, Driver) was available. Had a task list not been available, a list might have been generated by looking at the tasks performed on a predecessor system or by deriving functions to be performed from proposed capabilities of Block III.

The training analyst used the Blueprint of the Battlefield (Department of the Army, 1988) to organize the tasks on this list under broad functional categories (e.g., intelligence, survivability, fire control). Tasks organized according to the Blueprint structure are shown as Figure 1. Roman numerals designate the categories from the Blueprint of the Battlefield.

Next the analyst identified subcategories based on commonalities among tasks under each category. The subcategories (designated by capital letters) typically included several tasks but occasionally consisted of a single task. Finally, the analyst clustered the tasks (identified by Arabic numerals) at the appropriate level for the Phase I, II or III analyses. These task clusters typically included two or three tasks from a subcategory that were similar enough that the ET decision flowcharts could be applied uniformly to the entire cluster. In some cases a task cluster was comprised of a single task. This procedure generated twenty-nine task clusters.

Compiling Supporting Documentation

The validity of embedded training decisions is critically dependent upon gathering accurate information about the prime system, the training environment, and current training technology. This information is not typically available in a single document

I. Prepare to Move / Shutdown procedures
    A. Powerup/Prepare stations for operation
    B. Conduct preoperational checks
    C. After operations checks

II. Move
    A. Drive the tank
        1. Operate driving controls
        2. Operate the navigation system
        3. Tactical driving

III. Loading and Unloading

IV. Fire Control
    A. Estimate range (degraded)
    B. Classify and prioritize targets
    C. Issue fire command
    D. Execute fire command

V. Navigation
    A. Input route, waypoints
    B. Monitor navigation input

VI. Fire Support

VII. Air Defense

VIII. Command and Control
    A. Internal communications
        1. Initialize communications
        2. Control and operate intercom

    B. External communications
        1. Initialize communications equipment
        2. Construct/Edit messages or orders
        3. Transmit/Receive messages or orders
        4. Tactical communications
            a. Decision making
            b. Storing and retrieving information

Figure 1. Block III tasks organized by task category

Figure 1. (Continued)

IX. Intelligence
- A. Select/Set sectors
- B. Select sensors and mode
- C. Monitor sensors
- D. Acquire, identify and prioritize targets
- E. Aggregate and evaluate intelligence data
- F. Edit and send intelligence information
- G. Assess target damage/status

X. Mobility and Survivability
- A. Activate survivability systems
- B. Use communications security and countermeasures/electronic warfare
- C. Initiate NBC
- D. Decontaminate
- E. Reduce vehicle detectability
- F. Crew safety
  1. Detect/suppress fire
  2. Detect/eliminate standing fluid
- G. Mobility
  1. Ford water
  2. Cross gaps

XI. Combat Services Support (CSS)
- A. Conduct operator/crew maintenance
  1. Perform preventive maintenance checks and services (PMCS)
  2. Use maintenance aids
  3. Conduct scheduled/unscheduled maintenance
- B. Conduct resupply operations
- C. Use the training system
  1. Operate/use ET system
  2. Operate/use other training equipment
- D. Conduct vehicle recovery operations

and must be drawn from a variety of sources. These sources include both written documents and expert judgements from technical experts (e.g., project engineers, combat developers). Before proceeding with the task of assigning task clusters to training media, the analyst reviewed questions asked in each phase of the decision making process to determine the types of information needed to support the Phase I/II/III analyses. Available information was compiled and organized for each block of questions by analysis phase, and the required assumptions were recorded. Assumptions were necessary whenever the available information was insufficient to support the analyses. Data and assumptions needed to support the analysis for the Block III tank are included in Sections 4 through 6.

Constant Presets

For some questions in the decision aid, the answer remains constant regardless of the task or function under consideration. For those questions, the answer was preset (underlined on the flowchart prior to the analysis) to save time and effort in using the ET Guide. The questions treated in this manner may be referred to as constant presets. Constant presets may occur when insufficient information about a parameter forces the analyst to make assumptions regarding that parameter that apply uniformly across tasks. In other cases characteristics of the prime system, the training environment or specific policy statements may result in a given question always being answered the same way. For example the STRAP requires that the embedded training system include a fail-safe mechanism to prevent a weapon system from firing inadvertently during a training session. Therefore the answer to the question that asks if there is a need for a prime system fail-safe interface device (Phase III, Block 1) will be "yes", regardless of the task being considered. The STRAP also suggests that a dedicated instructor/operator will not be provided, but that unit personnel will perform the required instructional functions. Hence the answer (Phase III, Block 3) to the question that asks if a dedicated instructor/operator will be provided is preset to "no" and the answer to the question regarding the availability of other personnel for monitoring ET and providing feedback is preset to "yes". Phase III, Block 4 asks if existing training facilities can be used as is to support Block III training. The answer to this question was preset to "yes". Because there was nothing in the STRAP or other source documents to suggest that new facilities would be needed to support the Block III tank, it was assumed that existing facilities would be sufficient to support Block III training. If the information or assumption which provides the basis for a preset answer later proves to be false, the analysis can be revised based on the new information.

Using the ET Decision Charts in Making Recommendations

The analysis for each phase was based on the information and assumptions listed for that phase as described in Sections 4 through 6 of this report. Every effort was made to use only those data that could reasonably be expected to be available at the time that the analysis would normally be performed. However, it is probably impossible to completely exclude information that would only be available in the later phases from consideration when performing an analysis for an earlier phase. In addition the same task information was available for all phases of the analysis (although it wasn't used for Phase I analysis). Normally more detailed task information would become available as the analysis moved from one phase to the next because the phases would be performed at different times in the acquisition cycle.

Phase I decisions required only that tasks be separated into institutional and unit training tasks and did not require a separate analysis for each task cluster. Phase II and Phase III analyses, on the other hand, provided training media recommendations for each of the task clusters.

Multiple sets of the decision charts were made - one for each task cluster. This allowed each chart to be annotated during the decision making process, preserving a permanent record of the training recommendations and how they were reached. Chart annotations (in addition to the underlined constant presets) include the name of the cluster for which the decision was made, circles around answers or choices, and check marks to indicate the recommended training media. The analyst used different colors for making the chart annotations for institutional and unit training so that the same set of charts could be used for analyzing both. Occasionally, the analyst made written notations on the charts to support an answer to a question, particularly when the correct choice was not immediately obvious.

Each phase of the embedded training analysis was conducted independently with Phase I analysis preceding Phase II analysis and Phase II analysis preceding Phase III. A Phase IV analysis was not performed because the required data had not been generated. No attempt was made to complete the cost analysis worksheets, because much of the data required to complete these worksheets was not available. Data for completing Phase IV and cost analyses were not available because of the termination of the ASM Block III tank program by the Army.

Section 3. Problems in Using the ET Guide and Recommended Changes

Introduction

Several problems were encountered in applying the ET Guide to the ASM Block III tank program. Problems ranged from those associated with determining prime system availability to those requiring minor changes in the flowchart logic. This section describes the problems and tells how each was resolved.

Level of Analysis (Phase I)

The ET Guide recommends that the Phase I analysis be conducted at the system or mission level. After applying the Phase I procedures separately to several task clusters representing different missions, it became clear that the outcome of the Phase I analysis would be the same for all tasks and thus for all missions. Phase I analysis conclusions do not vary from one mission to the next, despite policy statements that favor ET for specific missions; therefore the analysis was conducted at the system level. The conclusions do vary depending on whether the * training being considered was to be delivered at the institution or in the unit. Hence separate analyses were required for institutional training and unit training. It is recommended that institutional and unit training be analyzed separately in Phase I whenever there is sufficient information to support separate analyses.

Networked Training Requirements (Phase II)

The ET guide provides no criteria for determining whether networked training requirements are likely for a particular task cluster. One potential criterion for making this decision is that the task is either a collective task that requires coordination between elements, or that it is an individual/crew task which changes in terms of skill demands when performed in conjunction with other elements in a simulated combat environment. Use of this criterion will provide a preliminary list of training requirements to be satisfied by a distributed simulation capability. The Phase II, Block 2 Help section should be revised, as shown in Appendix A, to include appropriate criteria for determining whether networked training requirements are likely.

Analysis of Training System Training Tasks (Phases II and III)

Training tasks (see Figure 1, task XI.C.) do not readily lend themselves to the analyses procedures because the flowchart questions are directed towards operations and maintenance tasks. It is suggested that all training tasks (e.g., teaching the

operator to use the ET system or how to train using a Stand-Alone Device) should be taught on their respective media.

Flowchart Logic (Phases II and III)

An additional question is needed on the Block 4 (Phase II) flowchart. The question is "Will sufficient numbers of prime systems be available to support appended training applications?". This question follows a similar question addressing whether sufficient numbers of prime systems will be available to support embedded training. In many cases, if sufficient numbers of prime systems are not available to support embedded training, the prime systems will not be available in sufficient numbers to support appended training applications. A question specifically addressing availability for appended training applications is needed, however, for those few cases in which the availability requirements of appended training systems differ from those of embedded training systems.

A logic error was found on Block 16 chart (Phase III), requiring the addition of a question to correct the logic flow. The new question reads, "Was ET or SAD recommended?". This additional question is necessary because there is no need to "Reduce requirements or increase support" if a suitable training alternative has already been recommended. The corrected flowcharts and revised help sections are included as Appendix A.

Prime System Availability (Phases II and III)

The analyst encountered some problems in projecting the availability of the Block III tank for training at the institution. The major problem was that different sources of information did not agree about the projected availability of the Block III tank at the institution. Estimates of prime system availability for the Phase II analysis were based on statements in the Required Operating Capability (ROC) (U.S. Army Armor School, March 1991) suggesting that most of the institutional training would involve the use of devices because of minimal availability of the Block III tank at the institution. In contrast, estimates derived from information supplied by the Armor School (just prior to conducting the Phase III analysis) suggested that the number of Block III tanks available for training at the institution could be considerably more than previously projected. Before performing the Phase III analysis, the availability of the Block III was reevaluated by looking at the availability (for training) of the M1A1 tank at the institution and assuming roughly equal availability for the Block III tank. This procedure resulted in a higher projected availability in the Phase III analysis than was projected in the Phase II analysis. Prior to conducting the Phase III analysis, it was determined that the number of Block III tanks at the institution would support roughly one-fourth to one-half of the tasks to be trained. While prime system availability may be

difficult to project, an estimate of availability is needed for determining the feasibility of using embedded systems for training a substantial portion of the operator or maintainer tasks and must be considered in the decision making process.

Institutional Versus Unit Training

The ET Guide includes specific questions for making separate decisions about institutional and unit training requirements for Phase II but not for the other phases. This does not preclude analyzing institutional and unit training separately in other the other phases, however. Usually, the information about training environments needed for rendering separate decisions about institutional and unit training will not be available during the Phase I Analysis. Whenever the required information is available, Phase I analyses should be separated into an analysis of institutional training and an analysis of unit training. In Phase III, when tasks allocated to institutional and unit training have been identified, institutional and unit tasks can be subjected separately to the decision making process. In the current trial application we found considering institutional and unit training separately during Phase I and Phase III analyses makes the analyses more sensitive to the different conditions existing in the two environments.

Section 4. Supporting Documentation, Assumptions, and Recommendations for Phase I Analysis of the Block III Tank

List of Documents Used in Phase I

Blueprint of the Battlefield (DA TRADOC, 1988)
Policy and Guidance Letter, Subject: Embedded Training (DA, 1987)
Required Operational Capability for the Main Battle Tank, Block III (USAARMS, March 1991)
Systems Training Plan for the Main Battle Tank, Block III (USAARMS, September 1991)

Supporting Data and Assumptions: Training Policies, Goals, and Constraints (Phase I, Block 1)

General Policy Statements

- An embedded training capability will be thoroughly evaluated and considered as the preferred alternative among other approaches to the incorporation of training subsystems in the development and follow-on product improvement programs of all army materiel systems (Department of the Army, March 1987)

Specific policies, goals and constraints (U.S. Army Armor School, March 1991)

- Embedded training system that trains individual crew tasks through force level collective tasks to combat standards is emphasized for sustainment and qualification training in the units (Block III ROC)

- Embedded training will reduce the need for maneuver training and range firing (Block III ROC)

- Number of Block III's at the institution is to be minimized by the heavy use of stand-alone devices (Block III ROC)

- Wartime reconstitution training of individual and collective tasks will be embedded if possible (Block III ROC)

- Embedded tactical engagement system (Block III ROC)

- Embedded maintenance training (Block III ROC)

Policy statements suggest that institutional and unit training should be considered separately in determining the applicability of embedded training. Policy statements indicate a preference for ET for unit training and a preference for SAD or appended devices for

institutional training. Additional policy statements suggest that embedded training is preferred for maneuver training, training that normally involves range firing, tactical engagement training, maintenance training and reconstitution training.

Supporting Data and Assumptions: ET Compatibility with Prime System Operations (Phase I, Block 2)

The Block III Systems Training Plan (STRAP) requires that a fully developed training subsystem, organic to and concurrently developed and validated with the hardware and software be in place at the fielding of the Block III tank (U.S. Army Armor School, September 1991). Hence concurrent fielding of the training system is required, and given the current milestone schedule for development of the Block III tank, concurrent fielding is likely.

The Block III tank need not be in the operational mode continuously. Therefore it can be switched to a training mode when embedded training is desired and switched back for operations. The STRAP requires that the time to convert the tank from a training mode to its combat mode be no more than 15 minutes. In this sense then ET should not interfere with operational use of the Block III tank.

Use of the tank controls and switches for embedded training may increase wear and tear on these components and hence adversely affect their operational use. Adverse impacts on operational use will only occur to the extent that increased RAM requirements resulting from the additional wear and tear cannot be met. Meeting the increased RAM requirements may require the use of more rugged components or possibly require additional maintenance manpower. The STRAP does not allow additional manpower to support ET; therefore components may need to be hardened to meet RAM requirements. At this time, we have no reason to believe that the required hardening of components used in both operations and training cannot be achieved. Therefore for most applications, ET should not adversely affect operational use of the Block III tank.

Supporting Data and Assumptions: MPT Requirements for Simulation Alternatives (Phase I, Block 3)

The Block III STRAP (U.S. Army Armor School, September 1991) includes the following information relating to MPT requirements:

> Embedded gunnery and tactical training capability in Block III will not increase manpower or force structure requirements.

The Block III Gunnery/Tactical embedded training system will not require any new Military Occupational Specialty (MOS) or increase the level of MOS requirement.

Neither the Block III Institutional Gunnery Trainer (IGT) nor the Institutional Driver Trainer (IDT) will increase manpower or force structure requirements.

Neither the Block III IGT nor the IDT will require any new MOS or increase the level of the MOS requirement.

The IGT and IDT will each require a dedicated Instructor/Operator in the schools and training centers.

The Tank Commander may require specialized type training to be able to apply the embedded training technology effectively.

Embedded maintenance training in Block III will not increase manpower or force structure requirements.

The Block III Operator Maintenance Embedded Training System will not require any new MOS or increase the level of MOS requirement.

Embedded training will be used to train Block III crewmembers. This may require the tank crew to have some specialized NET to apply the training technology effectively.

Constraints on manpower and new MOS's would seem to limit the types of ET to those that do not require a dedicated instructor/operator. The lack of a dedicated instructor/operator will increase the requirement for error catching routines and automated feedback functions in the embedded training system. The STRAP also prohibits any increases either in the MOS skill level or in the manpower levels in the MOS, but it does provide for additional training for the personnel that will use and operate the embedded training system. Therefore, MPT constraints may limit the forms that ET may assume, but do not severely limit the use of ET in general. The proposed SAD's (IGT and IDT) require a dedicated instructor operator as do their predecessor systems. Hence, lack of a dedicated instructor/operator is not a limiting factor for these stand-alone devices.

Phase I Recommendations

Phase I analyses yield the following recommendations, taking the foregoing information into account. SAD and some appended devices are the recommended alternatives for institutional training applications. Embedded training is the recommended alternative for

individual crew tasks through force level collective tasks for sustainment and qualification training in the units. The embedded training system must not require a dedicated instructor/operator, based on manpower and personnel restrictions. Because the outcome of this analysis did not limit embedded training to a particular type (i.e., fully embedded, appended ET, or umbilical ET), all types of embedded training systems are recommended and should continue to be considered. Embedded training is a preferred alternative for maneuver training, training that normally involves range firing, tactical engagement training, maintenance training and reconstitution training in the unit (based on policy statements), though it is generally recommended for other unit training as described above. Block III components that may be subject to wear and tear from embedded training use must be designed to withstand this additional usage.

Section 5. Supporting Documentation, Assumptions, and Recommendations for Phase II Analysis of the Block III Tank

List of Documents Used in Phase II

Blueprint of the Battlefield (DA TRADOC, 1988)
Baseline Cost Estimate for the Training Devices, Simulators and Simulation Required for the Armored Systems Modernization Program (Project Manager for Training Devices, July 1991)
Required Operational Capability for the Main Battle Tank, Block III (USAARMS, March 1991)
Systems Training Plan for the Main Battle Tank, Block III (USAARMS, September 1991)

Supporting Data and Assumptions: Safety and Training Requirements (Phase II, Block 1)

Safety. It is assumed that safety risks are increased in training that involves vehicle movement and firing of live rounds. It is further assumed that the degree of risk will increase as the number of vehicles simultaneously involved in the training increases. To the degree that embedded training and other simulation involve actual vehicle motion or live firing, risks associated with the training increase. Embedded training potentially involves an additional safety risk that live rounds may be inadvertently fired during training. The STRAP, however, requires that the embedded training system include a fail-safe mechanism to prevent a weapon system from inadvertently firing during a training session.

Predecessor system cost drivers. Predecessor systems for the Block III tank include the M1A1 and the M1A2. Both of these systems consume large quantities of fuel and use the 120mm gun and ammunition. The cost of operating these systems is high. The cost of preparing a tank for an exercise, the fuel cost to get it moving and the maintenance costs after the exercise is over have severely limited training opportunities (Saw, 1991a). When the costs of firing live rounds are added to this, the cost of training can be prohibitive. Another potential cost driver is the cost of upgrading ranges to handle the firing of the 120mm round. For tanks employing the 120mm gun, there is a legitimate training requirement to practice gunnery skills out to a range of 5000 meters (Saw, 1991b). If the required ranges have already been built for the predecessor system, then range construction is not a cost driver. When local training areas are inadequate for firing the main gun or for running larger scale exercises, transporting men and equipment to an adequate training area can be a major expense.

Device, simulators, and simulations cost drivers. If high fidelity simulators are required to augment, or substitute for, live fire, then their acquisition and support costs may become a cost driver. The production cost of the Institutional Gunnery Trainer for the Block III tank is estimated at roughly $ 1.8 million per copy and the Close Combat Tactical Trainer (successor to the Simulation Network or SIMNET) costs roughly $ 19.5 million to equip a tank battalion, or $ 375,000 per module (Project Manager for Training Devices, 1991). The Tank Precision Gunnery Inbore Device (TPGID), as a substitute for live fire, has the potential to reduce ammunition and maintenance costs and reduce the need for improved firing ranges, but a full research and development program and production funding for TPGID could run between $25 million and $100 million dollars (Saw, 1991b).

Embedded training system cost drivers. The Baseline Cost Estimate (BCE) for the Training Devices, Simulators and Simulation required for the Armored Systems Modernization Program (Project Manager for Training Devices, July 1991) lists the following as technical and cost risks:

a. probable increased vehicle RAM requirements resulting from ET.

b. use of the vehicle laser systems (Vehicle Integrated Defense System and Laser Range Finder) as a replacement for current tactical engagement simulation techniques.

c. miniaturization and adaptation of hardware to allow sufficient training simulation to be embedded within the normal confines of the combat vehicle (i.e., image generators, visual data base memory, thru-sight video optics).

d. the expensive embedded training system sustainment cost per vehicle would perhaps suggest a reduction in the total number of ASM vehicles being fielded with the "built-in" version of embedded training system. Configuration of the embedded training system as a "plug-in", instead of "built-in" might allow the flexibility to install the embedded training system only in certain vehicles, thus reducing the long term Operating and Maintenance (OMA) costs.

Other potential cost drivers not listed in the BCE include: networking ET systems together for collective training; and training crewmembers to use the embedded training system.

Supporting Data and Assumptions: MPT and RAM Requirements (Phase II, Block 2)

The Manpower Personnel and Training (MPT) requirements are identical to those listed for Phase I. By definition, ET requires the availability of the prime system for training purposes.

Furthermore the prime system must be available in sufficient quantities for a long enough time to allow soldiers to be trained. The following requirements listed in the Block III Systems Training Plan (U.S. Army Armor School, September 1991) should enhance the availability of the prime system for training purposes:

a. the requirement to embed Gunnery/Tactical Embedded Training System (G/TETS) into each Block III tank fielded. Because every fielded tank includes the ET system, training is readily available for every crew.

b. a capability to convert the tank from the combat to the training mode in not greater than 15 minutes.

The maintainability of the Block III is assumed to be sufficiently high that it should not be an important factor in determining availability for training.

Supporting Data and Assumptions: Training Support and Facilities (Phase II, Block 3)

If ranges and facilities are available to support the predecessor system in quantities equal to that of the Block III tank, then they should be adequate to support the Block III. This of course assumes that the Block III does not differ from the predecessor system on some critical parameter, such as range of the main gun. If the ranges and facilities for the predecessor system are inadequate, then the same may be said for the Block III. To the extent that the proposed embedded training system requires use of these ranges and facilities, it may or may not be supportable.

Supporting Data and Assumptions: Institutional Training Requirements (Phase II, Block 4)

Statements in the ROC suggest that much of the institutional training must be accomplished by devices, rather than by ET, because the expected number of tanks at the institution would be too few to support significant portions of the training required.

Supporting Data and Assumptions: Personnel and Skill Requirements for Unit Training (Phase II, Block 5)

Turbulence. It is assumed that personnel turbulence will continue to be a problem for training armor skills. The need for crew and unit coordination in armor units increases the impact of personnel turbulence on training and performance. It is further assumed that replacement personnel are likely to have low skill levels or decayed skills. Therefore the need to retrain and cross

train personnel to overcome the negative impacts of turbulence on collective performance is a very real requirement in armor units.

Skill requirements. The skill requirements for operating and maintaining the Block III tank are assumed to be high. This assumption is based largely on the increased capabilities of the tank over its predecessors. Some experts believe the Block III operating requirements will become more like those of present day aircraft. Certainly, the Block III will require the crewmen to learn and retain additional procedural tasks, which tend to decay rapidly, and to exercise a greater degree of decision making prowess, while perhaps reducing psychomotor requirements. The inclusion of a vehicle Position/Navigation system and other new system capabilities is likely to increase the number of procedural tasks that must be performed. Psychomotor tasks may be reduced by a multisensor target acquisition system and automatic tracking capabilities. In degraded modes, the psychomotor requirements may remain high, however.

Electronic links to other vehicles. Networking Block III tanks requires links with other Block III's and with networked simulation (SIMNET) modules. For the Block III tank, this could be accomplished through an umbilical connection or possibly through radio links. The capability of the current SINCGARS radio to provide the necessary radio link is unknown. The BCE suggests that linking the tank embedded training system to other simulations may employ microwave/satellite communications. Providing a capability to link Block III's together for collective training is well within the state-of the-art, particularly if we assume that much of the umbilical equipment will be housed in a mobile "electronics van". The requirement in the System Training Plan (STRAP) that the G/TETS interface with instrumented telemetry type ranges may provide another opportunity for linking vehicles to each other. Based on the foregoing discussion, it is assumed that the electronic links needed to meet networked training requirements will be available in the Block III tank.

Supporting Data and Assumptions: Workstation Availability for Training (Phase II, Block 6)

It is assumed that the students will be available for a sufficient amount of time to meet performance standards, and that prime system workstation availability will support ET if the prime system is available in sufficient quantities at the proposed training site.

Supporting Data and Assumptions: Training System Mobility (Phase II, Block 7)

Requirements documents do not specify that training be accomplished in assembly areas during wartime. Therefore, it is assumed that the embedded training system need not be available for training in assembly areas.

Phase II Recommendations

The most striking result of this process was the consistency with which embedded training was recommended for unit training across tasks. This is due in part to the tendency to answer many of the questions the same way for all of the task clusters. In addition, there are multiple paths to selecting the embedded training option. A lack of detailed information about the training facilities and support and the availability of the prime system for training determined the answers to key questions, resulting in the selection of an embedded training alternative. Some of the specific assumptions that determined the results include:

The required forms of support (e.g., facilities, personnel, supplies) will be collocated in sufficient quantity to make ET possible.

The MPT impacts of ET can be met.

Any additional wear and tear that ET places on the prime system components is supportable in terms of manpower and personnel impacts.

The prime system and the students will be available for a sufficient amount of time to meet performance standards.

The decision process indicated that all forms of embedded training, ranging from fully embedded training to umbilical ET, were recommended training alternatives. The mobility of the Block III tank coupled with task clusters that do not require a mobile training system led to this outcome.

In considering institutional training, SAD was recommended for the majority of the task clusters, primarily because it was expected that the prime systems would not be available in sufficient numbers at the institution to support training of the task clusters. Based on the limited availability of the Block III tank at the institution, embedded training was recommended for only four task clusters in Phase II analysis:

(1) Operate/use the ET system
(2) Supervise/conduct resupply operations
(3) Load/unload
(4) Power-up/prepare stations for operation.

Section 6. Supporting Documentation, Assumptions, and Recommendations for Phase III Analysis of the Block III Tank

List of Documents Used in Phase III

Blueprint of the Battlefield (DA TRADOC, 1988)

Baseline Cost Estimate for the Training Devices, Simulators and Simulation Required for the Armored Systems Modernization Program (Project Manager for Training Devices, July 1991)

Required Operational Capability for the Main Battle Tank, Block III (USAARMS, March 1991)

Systems Training Plan for the Main Battle Tank, Block III (USAARMS, September 1991)

Training Device Requirement (TDR) Block III Main Battle Tank Institutional Driver Trainer, Institutional Gunnery Trainer, and Gunnery/Tactical Embedded Training System (USAARMS, August 1991b)

Supporting Data and Assumptions: Safety and Data Security (Phase III, Block 1)

It is assumed that safety risks are increased in training that involves vehicle movement and firing of live rounds. It is further assumed that the degree of risk will increase as the number of vehicles simultaneously involved in the training increases. To the degree that embedded training and other simulation involve actual vehicle motion and live firing, risks associated with the training increase. Embedded training potentially involves an additional safety risk that live rounds may be inadvertently fired during training. The STRAP, however, requires that the embedded training system include a fail-safe mechanism to prevent a weapon system from inadvertently firing during a training session. The weapon system itself has traditionally been used in collective training exercises. For most, if not all, of the tasks to be trained, safety considerations would likely not be serious enough to preclude use of the prime system in training.

The need for data security depends on the type of data that resides in the system and the accessibility that operators will have to that data in the training mode. It is assumed that designers of the Block III tank will need to include a data security lock-out capability and that including the capability will be technically feasible.

Supporting Data and Assumptions: Skill Requirements (Phase III, Block 2)

The skill requirements for operating and maintaining the Block III tank are assumed to be high. This assumption is based largely on the increased capabilities of the tank over its predecessors. Some experts believe the Block III operating requirements will become more like those of present day aircraft. Certainly, the Block III will require the crewmen to learn and retain additional procedural tasks, which tend to decay rapidly, and to exercise a greater degree of decision making prowess, while perhaps reducing psychomotor requirements. The inclusion of a vehicle Position/Navigation system and other new system capabilities is likely to increase the number of procedural tasks that must be performed. Psychomotor tasks may be reduced by a multisensor target acquisition system and automatic tracking capabilities. In degraded modes, the psychomotor requirements may remain high, however.

Supporting Data and Assumptions: Prime System and Instructor Availability (Phase III, Block 3)

By definition, ET requires the availability of the prime system for training purposes. Furthermore the prime system must be available in sufficient quantities for a long enough time to allow soldiers to be trained. The following requirements (Block III STRAP) should enhance the availability of the prime system for training purposes:

a. the requirement to embed G/TETS into each Block III tank fielded.

b. a capability to convert the tank from the combat to the training mode in not greater than 15 minutes.

The maintainability of the Block III is assumed to be sufficiently high that it should not be an important factor in determining availability for training.

The Block III STRAP indicates that the G/TETS will have an adaptive evaluation system for evaluating the crew's progress and an instructor/operator station to aid in monitoring and critiquing student actions. The STRAP suggests that a dedicated instructor/operator will not be provided, but that the Tank Commander or other unit personnel will perform the required instructional functions. Based on the STRAP it is assumed that the MPT impacts of ET can be met.

Supporting Data and Assumptions: Training Ranges and Facilities (Phase III, Block 4)

If ranges and facilities are available to support the predecessor system in quantities equal to that of the Block III tank, then they should be adequate to support the Block III. If the ranges and facilities for the predecessor system are inadequate, then the same may be said for the Block III. If current ranges or facilities are not adequate, the option still exits to upgrade these facilities if the upgrading can be accomplished concurrent with Block III fielding and is affordable. To the extent that the proposed embedded training system requires ranges and facilities that are not and will not be available, ET is not supportable. It is assumed that existing ranges and facilities will be capable of supporting Block III tank training.

Supporting Data and Assumptions: Minimum Requirements for ET (Phase III, Blocks 5,6,7)

Given the scope of the training requirements listed for the G/TETS, it is unlikely that all of them could be met by a fully embedded training system or by an appended embedded training system. It will probably be necessary to meet some the requirements with an umbilical embedded training system or some other training alternative. In determining whether the minimum requirements for a particular type of embedded training can be met, each task or function will be treated as if it were the only task or function that the ET system would be required to support. If the sum total of the tasks or functions recommended for a type of ET exceed its capacity to support all of the tasks, then the excess tasks will be reevaluated to determine if they meet the minimum requirements for other ET alternatives. In determining whether minimum requirements for ET can be met, training developers and engineers will need to work closely with each other.

Supporting Data and Assumptions: ET Interference with Combat Operations (Phase III, Block 8)

The Block III Training Device Requirement (TDR) for G/TETS (U.S. Army Armor School, August 1991b) requires that the time to convert the tank from a training mode to its combat mode be no more than 15 minutes. There is no requirement to use the Block III in a training mode and operational mode simultaneously, nor is it likely that a Block III tank can or will be used simultaneously for training and operations.

Supporting Data and Assumptions: Visual System and Motion Requirements (Phase III, Block 9)

The TDR requires that G/TETS provide a realistic view of the outside world to the driver, gunner and tank commander from their individual perspectives. It must also represent stationary, moving and firing threat vehicles by type and ammunition effects to include tracer image and point of impact. The G/TETS will provide a realistic visual simulation of terrain and targets with scenarios that are programmable for individual, crew, platoon, company and battalion tactical/gunnery tasks. The TDR does not list a motion platform as a requirement and visual motion requirements (own tank and target movement) should be achievable in most cases.

Supporting Data and Assumptions: Prime System Advantages for ET Alternatives (Phase III, Block 10)

The Block III tank offers several general advantages for ET Alternatives as stated in the STRAP, TDR, or ROC. The Block III ROC suggests that the Vehicle Electronics (Vetronics) and the Vetronics Control and Operating System (VCOS) will provide electronic interfaces with crew controls and indicators. The Vetronics Control and Operating System also speeds information flow to high echelons. The ROC states that the Block III will be equipped with standard connectors to provide networked ET as required, and with umbilical connectors through which training devices/simulators will be appended when fully embedded training is not feasible. The TDR suggests the need for some automated instructional features to include the capability to monitor and evaluate the performance of crew(s) and provide feedback in the form of a report of past crew performance.

Supporting Data and Assumptions: Embedded Training Retrofit (Phase III, Block 11)

There is every reason to believe that training design decisions will be made early enough to incorporate ET in the Block III tank design, thereby avoiding a costly retrofit for ET.

Supporting Data and Assumptions: ET RAM Requirements (Phase III, Block 12)

The Block III TDR suggests that the G/TETS must meet the same RAM requirements for training as the Block III tank. It also states that the ET system must be no more vulnerable to threats than is the Block III. ET programs will reduce the need for maneuver training and range firing, thereby reducing maintenance costs and class III, V, and IX expenditures (Block III ROC, p. 1-

58). Hence, most uses of ET will not increase RAM requirements significantly, even though some additional wear and tear may occur. RAM requirements may also increase because of the additional on-board processing of data attending the introduction of Vetronics.

Supporting Data and Assumptions: Availability for Training (Phase III, Block 13)

By definition, ET requires the availability of the prime system for training purposes. Furthermore, the prime system must be available in sufficient quantities for a long enough time to allow soldiers to be trained. The following requirements (Block III STRAP) should enhance the availability of the prime system for training purposes:

a. the requirement to embed G/TETS into each Block III tank fielded.

b. a capability to convert the tank from the combat to the training mode in not greater than 15 minutes.

The maintainability of the Block III is assumed to be sufficiently high that it should not be an important factor in determining availability for training.

Availability for training at the institution may be reduced to the extent that there may not be enough Block III tanks at the institution to support the required training events. It is assumed that the allocation of Block III tanks to the institution will not support significant embedded training applications.

Supporting Data and Assumptions: Can Prime Systems or Their Workstations Support ET? (Phase III, Block 14)

Where there are sufficient numbers of prime systems available (e.g., in the unit), it is assumed that they can be made totally available for enough time to support ET. There is no requirement to use the Block III in a training mode and operational mode simultaneously, nor is it likely that a Block III tank can or will be used simultaneously for training and operations. While the individual crewmembers manning each crew workstation may train independently in some cases, they typically function as a crew during combat operations. Hence one crewstation would not be used for training while the other is used simultaneously for operations. While the Block III tank is a mobile prime system, the training system may or may not be required to be mobile based on the particular tasks or functions to be trained.

Supporting Data and Assumptions: Maintenance Considerations (Phase III, Block 15)

It is assumed that the training system components included in a fully embedded training system will be found in the Table of Organization and Equipment, and therefore will be maintained by Army personnel. It is further assumed that any component of an umbilical or appended ET system that appears in the TOE will be maintained by Army personnel. The TDR for the G/TETS attached to the Block III STRAP suggests that the embedded training system components will be maintained by the same personnel who maintain the tank. It is therefore assumed that sufficient Army personnel will be available for maintaining the ET system components. It is also assumed that a sufficient number of contract maintenance personnel to maintain those components that must be contractor-maintained will be available.

Supporting Data and Assumptions: Support for Stand-Alone Device (SAD) and Appended Training (Phase III, Block 16)

The TDR for the Institutional Driver Trainer (IDT) and the Institutional Gunnery Trainer (IGT) (U.S. Army Armor School, August 1991b) both indicate that dedicated Instructor/Operators will be provided. While the TDR limits the manpower and force structure to current levels, it should not restrict the use of Stand-Alone Devices because there is currently a cadre of support personnel who serve existing driver and gunnery trainers. Based on the lack of discussion of MPT problems in the TDR, it is assumed that MPT requirements for SAD can be met.

Supporting Data and Assumptions: SAD and Appended Training System Facilities (Phase III, Block 17)

The TDR suggests that Block III SADs will not require ranges, but will require training facilities. It appears that for the Block III, existing training facilities will provide adequate space for the SADs. The TDR requires that the IDT be able to fit into the existing driver training facility at Fort Knox. If appended devices are used they will likely require range facilities, but existing ranges should fulfill these requirements in most cases. Appended devices are unlikely to require any additional training facilities.

Supporting Data and Assumptions: Motion and Direct Vision Requirements for SADs (Phase III, Block 18)

The institutional training devices listed in the TDR suggest that a direct view of the outside world must be simulated. While the IGT requires only visual motion, the IDT requires a motion

platform as well. The motion platform will be an off-the-shelf system that has been in common use in industry.

Supporting Data and Assumptions: Appended Training Interference with Operations (Phase III, Block 19)

There is no requirement to use the Block III in a training mode and operational mode simultaneously, nor is it likely that a Block III tank can or will be used simultaneously for training and operations. While the individual crewmembers manning each crew workstation may train independently in some cases, they typically function as a crew during combat operations. Hence one crewstation would not be used for training while the other is used simultaneously for operations. The time to switch between a training mode and an operational mode will vary depending on the characteristics of the appended training system. The TDR does not provide this information for any potential appended training systems.

Supporting Data and Assumptions: Appended System RAM and Training Availability (Phase III, Block 20)

In the absence of information to the contrary, it is assumed that the RAM requirements for any proposed appended system can be met and that it will not cause undue wear and tear on the Block III tank. But if the appended training requires vehicle motion or live firing, the wear and tear will increase proportionately and Block III RAM may be affected. The availability of Block III tanks at the institution may be limited due to the cost of these systems. The use of appended training is limited by the number of prime systems that will be available and the number of soldiers that will be trained using the appended devices.

Supporting Data and Assumptions: SAD RAM and Training Availability (Phase III, Block 21)

Unlike embedded training or appended training, SAD does not require the availability of the prime system for training. However, the availability of SADs for training is dependent on the training load relative to the number of SADs installed at the institution or unit. The TDR requires that Block III SADs have an availability of 90% based on a 96-hour scheduled training week. The number of devices, the number of users and estimated training times are needed in determining availabilities. In the absence of such information, it must be assumed that the SADs will be available for training as required. The Block III STRAP indicates that the armor school will have 8 IDTs, 12 IGTs, and 13 Institutional Maintenance Trainers. Based on the STRAP it is

assumed that the RAM requirements established for Block III SADs can be met.

Supporting Data and Assumptions: Feasibility of Using Actual Equipment Training (AET) (Phase III, Block 22)

Based on the lack of discussion of MPT problems the TDR, it is assumed that MPT requirements for using the Block III tank for training can be met.

Phase III Recommendations

Unit Training. In keeping with the Phase II results, embedded training was consistently recommended for unit training. The only unit task that was not recommended for ET required the operator to learn to use other training equipment. As in Phase II, a lack of detailed information about the training facilities and support and the availability of the prime system for training determined the answers to key questions, resulting in the selection of an embedded training alternative. Most of the tasks could be trained using either fully embedded, appended embedded or umbilical ET systems. However, tasks that required simulation of own-tank movement could not be trained using either fully embedded or appended ET, and required an umbilical ET system. Current technology requires an umbilical ET system to provide the additional image generation capacity required for simulating own-tank movement. Five task clusters involve own-tank movement and thereby require an umbilical ET system:

Operate Driving Controls and Navigation System
Tactical Driving
Issue and Execute Fire Command from a Moving Tank
Ford Water and Cross Gaps
Conduct Vehicle Recovery Operations

The following clusters could be trained using fully embedded training, appended ET, or umbilical ET:

Power-up/prepare stations for operation.
Conduct Pre-op Checks/After Operation Checks
Load/Unload
Issue and Execute Fire Commands from a Stationary Tank
Classify and Prioritize Targets
Input Route/Waypoints
Monitor Navigation Input
Initialize Internal Communications & Operate Intercom
Initialize External Communications; Construct Edit Messages or Orders; Transmit/Receive Messages or Orders
Tactical Communications
Select/Set Sectors and Select Sensors and Mode

Monitor Sensors; Acquire, Identify and Prioritize Targets
Aggregate and Evaluate Intelligence Data; Edit/Send
Intelligence Information
Assess Target Damage/Status
Initiate NBC
Reduce Vehicle Detectability
Detect/Suppress Fire and Detect/Eliminate Standing Fluid
Supervise/conduct resupply operations
Operate/use the ET system
Perform Preventive Maintenance Checks and Services; Use Maintenance Aids; Conduct Scheduled/Unscheduled Maintenance

Institutional Training. The use of embedded training at the institution is limited somewhat by the lack of Block III tanks at the institution that may be devoted to training activities. An informal investigation into the use of the predecessor system at the Armor Center and School at Fort Knox suggests that the availability of the Block III tank may not be as restricted as the ROC seems to suggest. Assuming that the availability of the Block III should be roughly equal to the availability of the M1A1 tank at Fort Knox, the Block III should be available in sufficient numbers to train no less than one-fourth of the Block III tasks. If the Block III tank has a higher availability than estimated, then any of the unit tasks recommended for ET may also be trained at the institution. Conversely, if the availability has been overestimated, then some of the tasks suggested for ET may have to be trained using other training system alternatives. A reanalysis of institutional training for the Block III tank will be required if the estimated availability of the Block III tank at the institution changes. Based on these assumptions and analysis using the ET Guide, the following task clusters may be trained via embedded training at the institution:

Power-up/Prepare Stations for Operation
Load/Unload Main Gun
Input Route, Waypoints
Monitor Navigation Input
Select/Set Sectors; Select Sensors and Mode
Monitor Sensors; Acquire, Identify, & Prioritize Targets
Aggregate & Evaluate Intelligence Data; Edit & Send
Intelligence Information
Assess Target Damage/Status
Initiate NBC

SAD was recommended for training the remaining institutional tasks. Generally speaking, the task clusters recommended for SAD were those tasks that would require much training time or would typically be performed in conjunction with tasks requiring considerable training time.

Some of the specific assumptions that were primary determinants of the results include:

The required forms of support (e.g., facilities, personnel, supplies) will be collocated in sufficient quantity to make ET possible.

The MPT impacts of ET can be met.

Any additional wear and tear that ET places on the prime system components is supportable in terms of manpower and personnel impacts.

The prime system and the students will be available for a sufficient amount of time to meet performance standards.

The recommendations provided as the result of the Phase III analysis are based on a detailed analysis of the best available information to date. Therefore the conclusions reached during Phase III analysis supersede the earlier conclusions based on Phase I or Phase II analyses. Where conclusions differ, those reached during Phase III take precedence.

Section 7. Conclusions

Lessons Learned

Application of the ET Guidelines to the ASM Block III tank demonstrates that the guidelines can be used to make objective recommendations about the use of embedded training for a major weapons system program. Perhaps the most difficult part of applying the guidelines is identifying and organizing the tasks and functions in preparation for the embedded training analysis. Another necessary, but difficult, task involved identifying and locating the information that was needed to be able to answer the flowchart questions accurately. Few problems were encountered in using the decision flowcharts once the necessary data had been assembled. Changes to some of the flowcharts and help screens are recommended, however, based on this trial application. These are described in Section 3 and the revised charts and help screens are included as Appendix A.

Utility of Results

At the time the decision was made to use the Block III Tank as a test case for the ET Guidelines, the Block III was a viable ongoing program. Subsequently, the Army made a decision to halt the program based on a change in the threat and budget considerations. This decision had little effect on the trial application of the guidelines because most of the information needed to apply the guidelines (through Phase III) had already been generated. The decision to halt the program however does have a direct effect on the utility of the specific recommendations for embedded training in the Block III tank described in Section IV of this report. If the Block III tank program is resumed at a later date, the analysis may have to be redone because technology changes are likely to impact both the Block III tank design and the feasibility of using a fully embedded training system.

The trial application of the ET Guidelines to the Block III tank has important implications for determining the embedded training requirements for other ASM vehicle systems. Many of the factual statements and assumptions listed for the Block III tank in Sections 4 through 6 will apply to other ASM vehicles such as the Advanced Field Artillery System (AFAS). The issues of vehicle availability at the institution and the use of networked training requirements will have to be resolved for other ASM vehicles. The discussion of these issues in this report should help analysts to better address these issues for other ASM systems.

The chore of keeping track of the decision process is formidable in that each task or function analyzed produces a large number of annotated charts that must be organized and reviewed to

complete the analysis. The complexity of the embedded training analysis for the ASM Block III tank suggests that an automated version of the ET Guidelines is needed to facilitate the analysis process. In response to this need, STRICOM has recently completed an automated version of the Guidelines (R. Copeland, personal communication February 12, 1992).

Finally, the successful application of the ET Guidelines to a major weapons system provides empirical support for the utility of the Guidelines in making embedded training decisions. In addition to the benefits derived from refining procedures required for using the ET Guide, this report clearly demonstrates how early embedded training decisions can be made objectively using the ET Guide. It shows training developers and materiel developers that the ET Guide is a useful tool that can help them perform their jobs more effectively.

Section 8. References

Department of the Army. 1987, March. Policy and Guidance Letter, Subject: Embedded Training. Washington, D.C.

Department of the Army Training and Doctrine Command (TRADOC). 1988. Blueprint of the Battlefield. (TRADOC Pamphlet No. 11-9). Ft. Monroe, VA: Headquarters, United States Army Training and Doctrine Command.

Project Manager for Training Devices. 1991, July. Baseline Cost Estimate for the Training Devices, Simulators and Simulation Required for the Armored Systems Modernization Program. Orlando, FL: Project Manager for Training Devices.

Saw, David. Issue 5, 1991a. Tank training some issues. Military Simulation and Training, pp. 14-16.

Saw, David. Issue 5, 1991b. Tank training solutions - TPGID. Military Simulation and Training, pp. 17-19.

U.S. Army Armor School. 1991, March. Required Operational Capability for the Main Battle Tank Block III. Fort Knox, KY: U.S. Army Armor School.

U.S. Army Armor School. 1991a, August. Block III Task List (Draft). Fort Knox, KY: U.S. Army Armor School.

U.S. Army Armor School. 1991b, August. Training Device Requirement (TDR) Block III Main Battle Tank Institutional Driver Trainer, Institutional Gunnery Trainer, and Gunnery/Tactical Embedded Training System . Fort Knox, KY: U.S. Army Armor School.

U.S. Army Armor School. 1991, September. Systems Training Plan for the Main Battle Tank Block III. Fort Knox, KY: U.S. Army Armor School.

Witmer, B.G., and Knerr, B.W. 1991. A guide for early embedded training decisions. (ARI Research Product 91-14). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A239 669)

APPENDIX A

Revised Flowcharts and Help Sections

Phase II. Block 2 Help

Purpose: The purpose of this block is to evaluate the capability of the prime system to support ET, considering the impacts of ET on manpower, personnel, and training (MPT) and on system reliability, availability and maintainability (RAM).

Rationale: The effective utilization of a training system depends on bringing together the resources needed to train at the appropriate time and place. Adequate numbers of skilled personnel to conduct the training, compatible facilities, and the necessary supplies must be present to properly utilize the embedded training system. Without information to the contrary, it can be assumed that the required support for conducting embedded training will be provided. However, note that organizational factors and funding may limit the types of support that can be provided. If the necessary support for ET is unavailable, then questions in Block 3 are asked to determine if alternative forms of training can be supported. If ET appears to be supportable then the impact of the additional wear and tear on the prime system is examined. If this impact results in an unacceptable maintenance load, then the possibility that ET can be designed so that it does not adversely impact the prime system is explored. If ET cannot be designed to eliminate the adverse impacts of embedded training on the prime system, the questions in Block 3 are asked to determine if other simulation alternatives are supportable. If ET can be designed so that it does not unduly stress the prime system or the impact can be supported, then it is determined whether the prime system can support networked embedded training requirements. Networked training requirements will be likely if either of two task conditions are met: (1) the task is a collective task that requires coordination between elements; or (2) the task is an individual or crew task which changes in terms of skill demands when performed in conjunction with other elements in a simulated combat environment. If networked training requirements are likely but cannot be supported by ET because it is not feasible to provide the necessary electronic interfaces, then these requirements must be met by networked stand-alone devices. If prime system characteristics can support networked training, or if networking is not required, then ET is considered further in Block 4.

Phase II. Block 4 Help

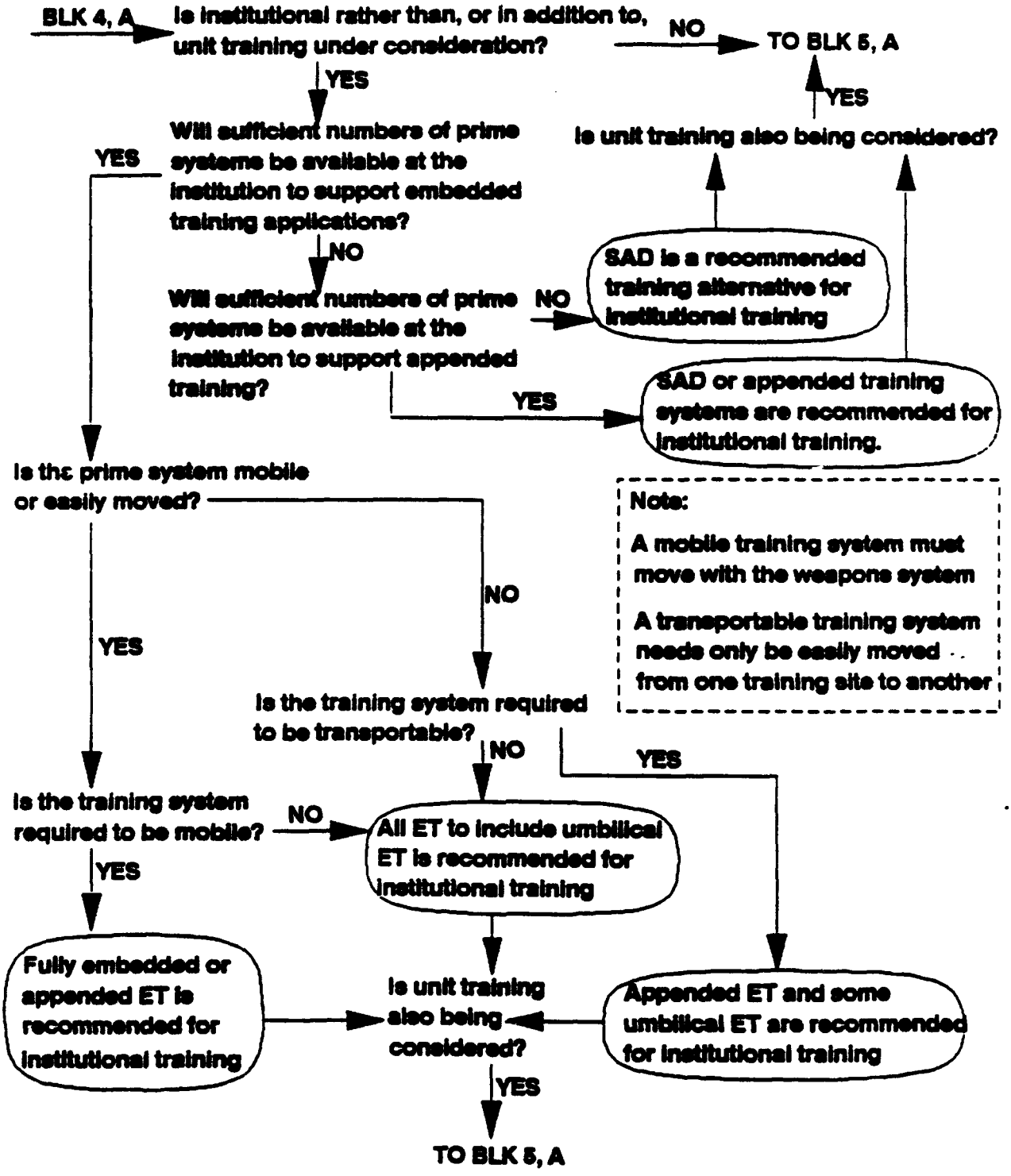
Purpose: The purpose of this block is to differentiate among the various types of embedded training and training devices based on their capabilities to satisfy institutional training requirements during both peacetime and mobilization.

Rationale: If institutional training is being considered, the availability of a sufficient quantity of prime systems to support embedded training at the institution is assessed. If the numbers of prime systems available at the institution cannot support ET, but can support appended training, then either SAD or appended training are the recommended alternatives for institutional training. If the numbers of prime systems available at the institution can support neither ET nor appended training, then SAD is recommended for institutional training. If, on the other hand, a sufficient number of prime systems are available for institutional training, then requirements for training system mobility and transportability are considered.

A mobile training system must by definition move with the prime system. One reason to require the training system to move with the prime system is to use the training system in realistic moving vehicle exercises. Another reason is to make the training readily available to soldiers wherever they take their prime system. A transportable training system is one that can be moved from one training site to another relatively easily, but must be moved apart from the prime system. As defined here a transportable system should not require extensive preparation for relocation.

If the prime system does not move easily and the training system must be transportable from one training site to another, then only appended ET or umbilical ET are applicable because fully embedded system must stay with the system to which it is embedded. If the training system need not be moved then all types of ET to include fully embedded can be used with an immobile prime system. If the prime system can move easily and the training system is required to move with it, fully embedded or appended ET are the best alternatives because they typically reside on the vehicle. If the prime system can move easily, but there is no requirement for the training system to move with it, then all three types of embedded training are options for meeting the institutional training requirements. After determining the best options for meeting institutional requirements, the analyst may want to consider unit training requirements in Block 5.

Phase II, Block 4. Which types of ET or simulation alternatives meet institutional training requirements?



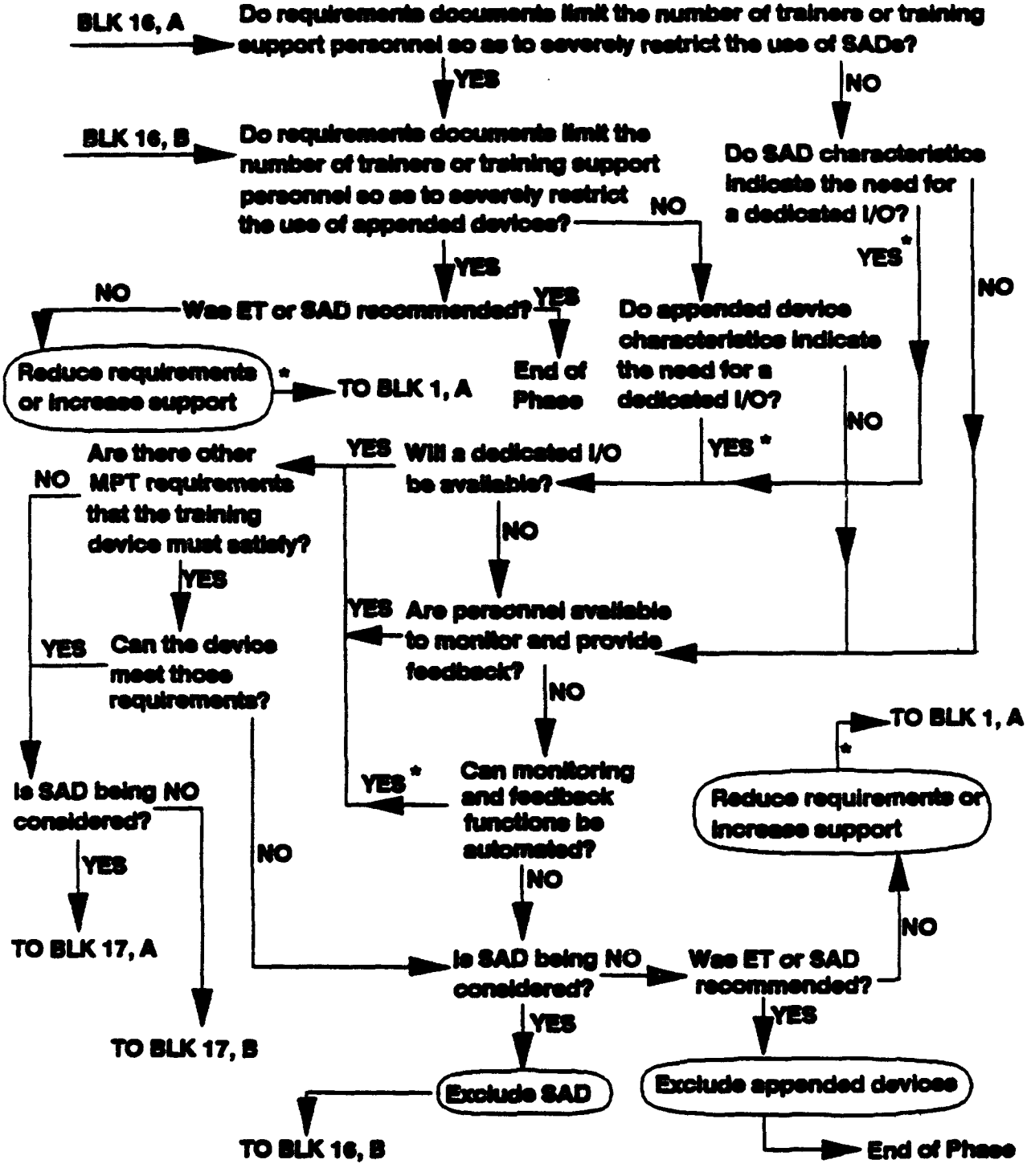
Phase III. Block 16 Help

Purpose: The purpose of this block is to identify factors that may limit or restrict the use of stand-alone devices (SADs) or appended training devices for meeting training requirements. Requirements documents may restrict the use of SADs or appended devices by limiting training support personnel (including those who support training as a secondary duty) or the number of training systems that are to be fielded.

Rationale: The effectiveness of a training device may be affected by the number of training systems fielded (which in turn affects the availability of the device) and the number and types of personnel available to support the fielded systems. If requirements documents fail to allocate a sufficient number of training devices or the personnel required to support them, then either training requirements must be reduced or the training device support must be increased. Increased support might consist of additional instructional or maintenance staff or an increase in the number of devices provided. If support cannot be increased then requirements may have to be reduced. One way to reduce training requirements is to redesign the prime system so that less training is required to operate or maintain it. Requirements for additional instructional support can be reduced by automating many of the instructional functions, and requirements for maintenance support can be reduced by making the prime system more reliable and easier to maintain. Changing the support provided or requirements entails a reevaluation of Phase III, starting with Block 1 questions.

For training systems not restricted by constraints imposed in requirements documents, a dedicated instructor/operator (I/O) must be available if needed unless other personnel are available to perform the necessary instructional functions, such as monitoring student performance and providing feedback. If personnel are not available to perform these functions, then a training device may still be an option if performance monitoring and feedback functions can be accomplished by designing a training device with automated instructor features. If a training device can meet the specific instructor requirements examined in this block, and it can satisfy other Manpower, Personnel and Training (MPT) requirements, then the training device is considered further in Block 17. If not, the training device option being considered is excluded. If the device option excluded is SAD, then appended devices are considered in Block 16, B. If the appended device option cannot be adequately supported, and no other training system alternatives were recommended, then either training requirements must be reduced or support must be increased. Changing either support or requirements entails a reevaluation of Phase III, starting with Block 1 questions.

Phase III, Block 16. Do the number of trainers or support personnel allowed by requirements documents limit the use of SAD or appended training devices?



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